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ABSTRACT

This discussion of methods used to assess the effectiveness of training for U.S. Army personnel identifies various types of training, describes methods currently used, and suggests ways of improving the assessment process. The methodology and results of assessments of effectiveness, including the costs associated with the level of performance, are reported for three types of training: (1) flight simulators, which have been evaluated on the basis of transfer of training; (2) computer based instruction, including both computer assisted and computer managed instruction as compared with conventional instruction; and (3) maintenance simulators used to train technicians how to perform routine maintenance, diagnose malfunction, and replace faulty parts. Findings indicate that, while these methods of training are generally found to be as effective as the more conventional methods, their effectiveness has been measured only at schools and not subsequently on the job, and only limited cost data are available. A 14-item reference list and 14 figures are provided. (LMM)

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CURRENT KNOWLEDGE AND PROJECTION ON ASSESSING THE EFFECTIVENESS OF TRAINING

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ABSTRACT

The effectiveness of training can be assessed on the basis of how well students perform in school and afterwards on the job and in combat-like operations and exercises. Since the level of effectiveness that can be achieved is influenced by the amount of resources and the amount of time allocated to training, it is necessary to evaluate the cost as well as the effectiveness of training. Data on the effectiveness and cost of three types of training are evaluated: flight simulators, computer-based instruction and maintenance simulators. Findings are that these methods of training are as effective as the more conventional methods to which they were compared; however, effectiveness has been measured only at schools and not subsequently on the job. These methods of training cost less to acquire and use, but only limited cost data are available. Recent developments may provide the required data on job performance in the areas of maintenance and field engagements.

PURPOSE

The purpose of this paper is to describe methods used presently to assess the effectiveness of training, and to suggest ways of improving our ability to make such assessments.

BACKGROUND

Military training will cost $12.8 billion to train 1.8 million students at 138 different facilities in Fiscal Year 1983 (Figure 1). Most of this training (about 75 percent) is initial training to turn civilians into useful members of the military services, e.g., mechanics, cooks, radar operators, truck drivers, pilots, clerks, and so on. This is called "individual training;" it is also called "institutional training" because it takes place at various schools. Those who complete this training are assigned to operational commands for additional training as members of crews, units, or groups; the Army calls this "collective training." About 20 percent of all military man-years are spent each year at various schools by students and instructors (Figure 2).

ASSESSING THE EFFECTIVENESS OF TRAINING

How does one assess the effectiveness of training? At the outset, we should realize that there are various types of training and that each may require its own special method of assessment. It is also important to understand that, even though we may focus on the issue of effectiveness, it is impossible to disregard the complementary issue of cost. A suggested framework for assessing various types of training is given in Figure 3.

The types of training identified here follow an obvious progression from initial training at school to advanced training on the job, followed by training in combat-type exercises in the field. There is also a progression from individual training to collective training, i.e., from learning how to do one's own job to learning how to work jointly with others. The ultimate criterion of the effectiveness of individual and group training is overall effectiveness in combat. We could say that, except for when engaged in combat, all military activities are part of training to be ready for combat. Effectiveness of training at school is measured in such terms as grades in courses or scores on tests, the ability of students to complete a course in the allotted time, and in the amount of attrition (i.e., failure to complete a course).

The effectiveness of training should really be measured in terms of performance on the job, e.g., ability to diagnose malfunctions and to replace faulty parts, the amount of time needed to repair equipment, ability to operate tanks and radars, and to bake a bread in a field oven. However, this type of objective performance data is almost never collected; some efforts are made to relate supervisors' ratings of job performance, i.e., subjective data, to adequacy of training in selected courses.

Training on the job might be evaluated in such ways as by performance on Skill Qualification Tests (being developed by the Army), by the amount of time needed to qualify for advancement in ratings, and/or by the ability, over time, to handle tasks of increasing complexity. A major problem with some of these measures is the subjective nature of the evaluation of adequate job performance. Advancement in grade is not only the result of acceptable job performance; it can also be a function of the amount of time on a job and the result of a policy to maintain (or improve) motivation by means of advances in pay and status. In any case, the proper measure of performance on the job should be performance in field exercises. Here the

FIGURE 1. Number of Students and Costs of Various Types of Individual Training at Military Schools, FY 1983

TYPE OF INITIAL TRAINING	NUMBER OF STUDENTS (INPUT, 000)	COST	APPROXIMATE COST/STUDENT
RECRUIT	363	$ 871 M	$ 2 K
ONE-STATION UNIT TRAINING (ARMY)	119	332	3
OFFICER ACQUISITION	20	376	19
SPECIALIZED SKILL	1,347	2,883	2
UNDERGRADUATE FLIGHT	18	1,825	100
PROFESSIONAL DEVELOPMENT EDUCATION	35	427	12
MEDICAL	—	431	
SUPPORT, MGMT, TRAVEL, PAY	—	5,626	
TOTAL		$12,771	

Source: MMTR for FY 1983

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FIGURE 2. The Amount of Time Spent by Students and Instructors in Individual Training at Military Schools, FY 1983

	MAN-YEARS (000)	
	MILITARY	CIVILIAN
STUDENTS	255	—
INSTRUCTORS	133	59
TOTAL	388	59
DoD END-STRENGTH	2148	1035
PERCENT IN TRAINING	18%	6%

Source: MMTR for FY 1983, SecDef Annual Report, FY 1983.

8-24-82-6

FIGURE 3. Framework for Assessing Various Types of Training

TYPE OF TRAINING	METHOD OF ASSESSMENT	
	EFFECTIVENESS	COST
SCHOOL		
ON-THE-JOB		
FIELD EXERCISE		

8-25-82-35

major problem is obviously an inability to relate large-scale measures of group performance, (e.g., tanks "killed," aircraft "detected,") to the performance of smaller units or of individuals.

It is easy to overlook the fact that resources are required to achieve any level of effectiveness, and that the amount of resources provided for training can readily influence the level of effectiveness that may be achieved. Thus, it is quite meaningless to consider the effectiveness of training without also considering, at the same time, the cost associated with that level of performance.

We consider next assessments of three types of training: the use of flight simulators in flight training, the use of computer-based instruction in technical training at school, and the use of maintenance simulators for training maintenance personnel. Attention will be given primarily to the methods used in assessing the effectiveness of these types of training; the issue of costs will not be overlooked.

FLIGHT SIMULATORS

The effectiveness of flight simulators has been evaluated on the basis of transfer of training, i.e., by determining the extent to which flight skills, such as landing or instrument flight, learned in a simulator can be performed successfully in aircraft. Positive transfer was demonstrated spectacularly in the Apollo program where astronauts, trained only in simulators, landed successfully on the surface of the moon on their first trial. About 140 different simulators were used for various types of training in the Apollo program. The Federal Aviation Administration now permits the use of flight simulators for transition training and qualification; after qualification in a simulator, pilots are now permitted to fly new aircraft for the first time on a revenue flight with passengers. Both of these examples (e.g., Apollo and FAA) imply 100 percent transfer.

The amount of transfer from simulator to aircraft for any particular task, such as landing, can be determined in the following way: establish how long (or how many trials) it takes pilots trained only in aircraft to be able to perform a particular task at a specified level of performance and compare that to how long (or how many trials) it takes a similar group of pilots to perform the same task to the same criterion in aircraft after learning to perform the task in a flight simulator. An index, called the Transfer Effectiveness Ratio, measures the amount of flight time saved as a function of the amount of time spent in the simulator (Figure 4).

Transfer effectiveness ratios for 34 tasks are shown in Figure 5. They range in value from -0.4 to 1.9, with a median value of 0.48. The data show that pilots trained in simulators needed less time in aircraft to perform acceptably than pilots trained only in aircraft; the amount of flight time saved was about one-half of the time spent in the simulator. There is a wide range in these TERs; clearly, these flight simulators were not equally effective in saving flight time in all cases, and it seems important to identify the factors that make for efficient and inefficient use of simulators. To the best of our knowledge, this has not been done.

Good data are also available on how much it costs to use flight simulators and aircraft (Figure 6). During Fiscal Years 1980 and 1981, the median ratio of variable operating costs for 42 flight simulators and aircraft was eight percent. Since the amount of flight time saved by the use of simulators is about 50 percent of the time spent in simulators, and since simulators cost less than ten percent as much to use as aircraft (median values in

FIGURE 4. Transfer Effectiveness Ratio (TER)

$$TER = \frac{A - A_S}{S}$$

A = AIRCRAFT TIME, WITHOUT SIMULATOR

A_S = AIRCRAFT TIME, AFTER SIMULATOR

S = SIMULATOR TIME

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FIGURE 5. Transfer Effectiveness Ratios for Various Types of Flight Training, Based on 22 Studies Performed 1967-1977

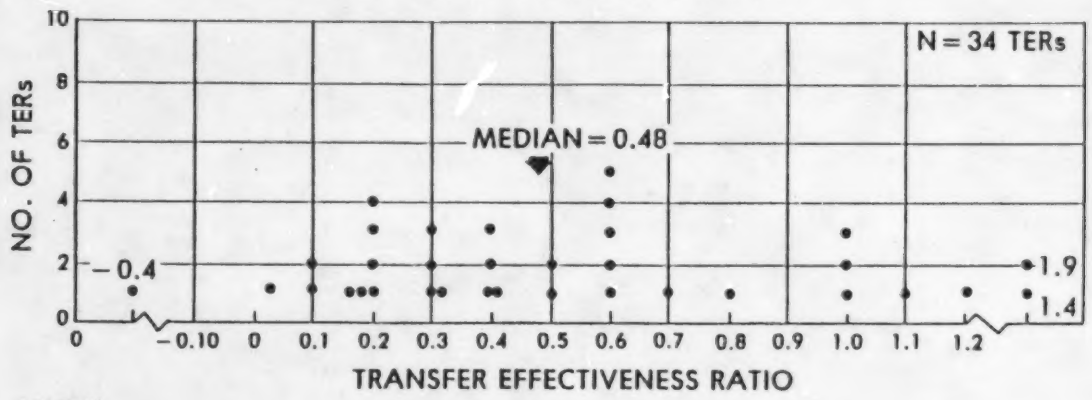

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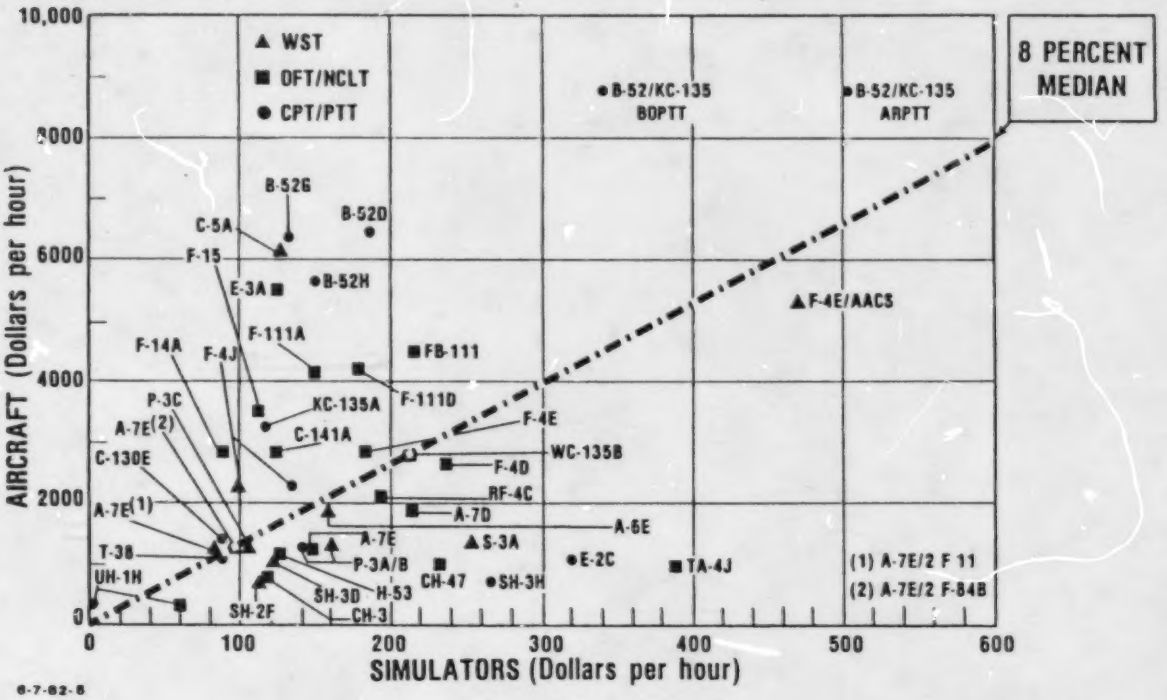
FIGURE 6. Variable Operating Costs Per Hour for 42 Flight Simulators and Aircraft, FY 1980 and FY 1981



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both cases), it is clear that flight simulators are cost-effective for flight training.

This finding does not mean that all flight simulators are equally effective for training on all tasks. Some of the TERs in Figure 5 are quite low, i.e., 0.1 or less. Nor does this finding mean that any one simulator is equally effective for all tasks for which it might be used. According to Figure 7, TERs varied from 0.0 to 2.8 for 24 different maneuvers in the same simulator for the CH-47 helicopter. Since there is a learning curve, the incremental effectiveness of a simulator is reduced as training time increases (Figure 8). A simulator should be used for flight training on any particular task as long as the TER is larger than the simulator/aircraft operating cost ratio and not when it is less than that ratio.

In the Povenmire and Roscoe (1973) study (Figure 9), the cross-over point was where the cost ratio and the TER were both about 0.7. Based on the cost data currently available, the median cross-over point is at about 0.10. Thus an adequate assessment of training needs information about effectiveness, transfer of training and cost, and this information is available in the case of flight simulators.

COMPUTER-BASED INSTRUCTION

Computer-assisted instruction (CAI) and computer-managed instruction (CMI) are significant alternatives to conventional classroom instruction, particularly for specialized skill training where it is possible to specify what a course graduate should know and be able to do. Figure 1, shown earlier, shows that over 1.3 million students will receive skill training at a cost of about $2.9 billion in Fiscal Year 1983.

In CAI, the student receives all of his instruction at a computer terminal; lessons are presented on the screen, and the student responds by using a keyboard or by touching the screen. In CMI, the student works on his lessons in a learning carrel or at a laboratory bench, i.e., away from a computer terminal. However, the student takes a test on each lesson, typically about an hour of work. The computer scores the test, interprets the results for the student and directs him to the next lesson or to repeat the last one. A key feature of CAI and CMI is that each student proceeds at his own rate of learning, called "self-paced instruction." By contrast, in conventional classroom instruction all students proceed at the same pace (although it is well known that students differ markedly in their rate of learning).

Another feature of CAI and CMI is that students receive prompt feedback. In conventional instruction, feedback is received over longer intervals whenever tests are given, and results are reported to students; the instructional value of tests is diminished if there is any delay in receiving the results. Two of the better known CAI systems are PLATO and TICCIT; the Navy has a CMI system at the

FIGURE 7. Transfer Effectiveness Ratios for 24 Maneuvers, CH-47 Flight Simulator (Trials to Criterion)

MANEUVER	TER
Four wheel taxi	2.80
Cockpit run up	1.50
SAS off flight	1.33
Deceleration	1.25
Maximum take off	1.25
General air work	1.00
Steep approach	1.00
Two wheel taxi	1.00
Confined area recon	1.00
Hovering flight	.79
Normal take off	.75
Confined area approach	.75
Landing from hover	.69
External load briefing	.67
Take off to hover	.63
Traffic pattern	.61
Shallow approach	.58
Normal approach	.53
Confined area take off	.50
External load take off	.50
External load approach	.50
Pinnacle recon	.50
Pinnacle take off	.33
Pinnacle approach	.00

Source: Helman (1979).

FIGURE 8. Hours Needed for Final Flight Check, Piper Cherokee

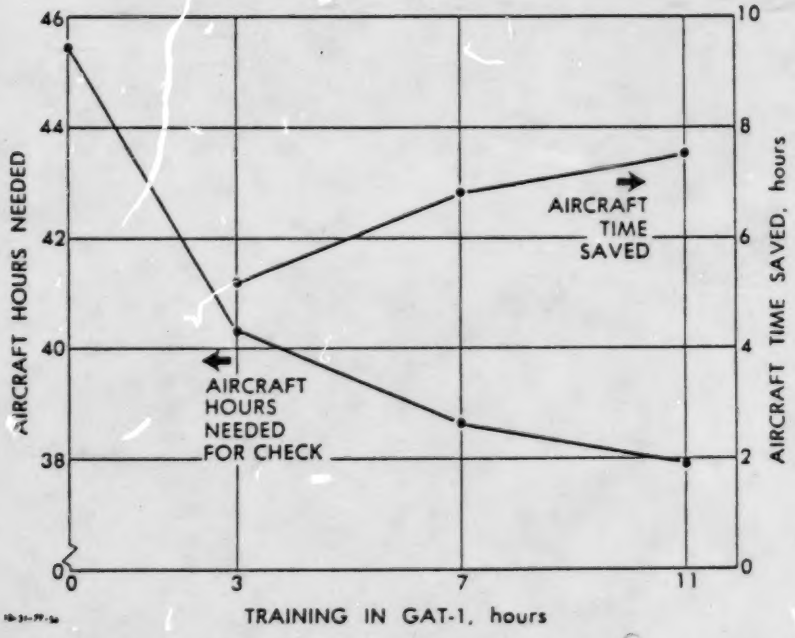
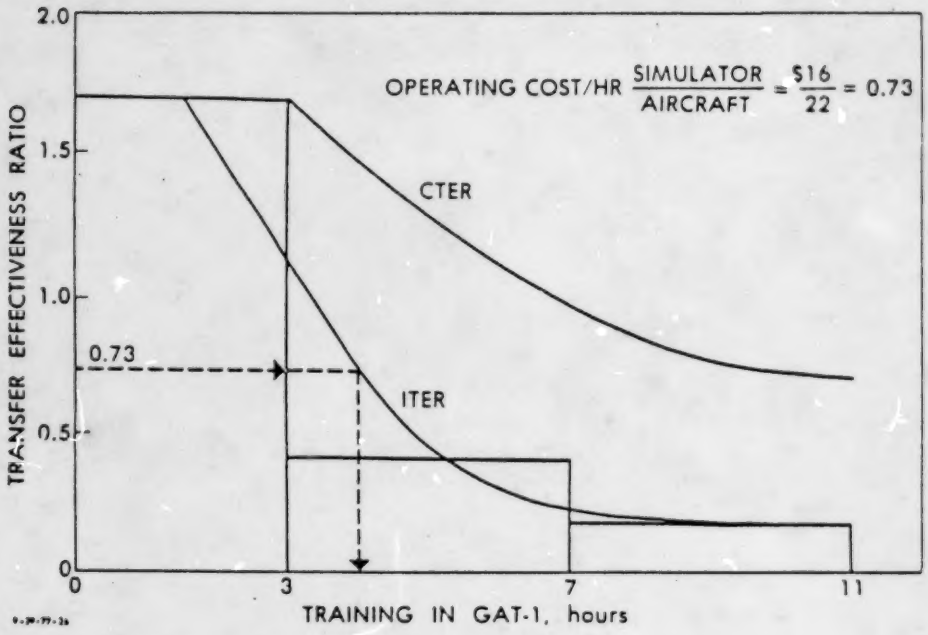


FIGURE 9. Incremental Transfer Effectiveness Ratio (ITER) and Operating Cost Ratio



Source: Povenmire and Roscoe (1973).

Naval Technical Training Center, Millington, Tennessee, and the Air Force has one (the Advanced Instructional System) at Lowry Air Force Base, Denver, Colorado.

The relative effectiveness of CAI and CMI, compared to conventional instruction, has been addressed in 48 studies, conducted from 1968 to 1979, that are summarized in Figure 10. Using end-of-course grades and scores on tests as a measure, these studies compare achievement of students in the same courses when taught by conventional instruction or by CAI or CMI. Such comparisons were made for six different CAI systems and two different CMI systems in a wide variety of military, technical training courses. Student achievement with CAI or CMI, compared to conventional instruction for the same course, is shown in the figure either as "inferior," "same," or "superior;" the result of each study is represented by a dot placed in the appropriate column. The figure shows clearly that student achievement at school with CAI or CMI is about the same as, or in some cases superior to, that with conventional instruction. The amount of superior achievement (i.e., higher scores) is small.

We can say that CAI and CMI are as effective at school as conventional instruction. We do not know whether course grades, test scores, or successful completion of a course predicts performance of graduates on the job. There are no transfer type data available for CAI, CMI or conventional instruction. Data are needed that describe how well students perform on the job after training in the relevant course material at school.

Data that compare the costs of CAI, CMI and conventional instruction are also incomplete. It is known, of course, that the costs of computers have come down markedly over the last ten years. However, the development of software and courseware depends on highly qualified manpower and this cost has been increasing over the last ten years. Assessments of the PLATO IV CAI system during the 1975-1977 period suggested that it was marginally cost-effective; about the same was found for the Air Force Advanced Instructional System (CMI) in 1978. These assessments did not use complete cost data and do not provide a credible basis for current judgments. The relative costs of CAI and CMI and conventional instruction is still a moot issue.

What is not moot is that the use of CAI and CMI can save some of the time needed by students to complete the same courses when given by conventional instruction. Because of self-pacing in computer-based instruction, students who can learn faster are not held back by the pace set for average students in conventional, group-paced instruction. The relevant data, drawn from the same studies that reported student achievement above, are shown in Figure 11. The amount of student time saved by CAI or CMI, compared to conventional instruction, shows a very wide range--from -30 percent to as much as 85 percent (i.e., in a few cases, CAI or CMI took more time). The median value is

FIGURE 10. Student Achievement at School: CAI and CMI Compared to Conventional Instruction

METHOD OF INSTRUCTION	SYSTEM	SERVICE	LOCATION	STUDENT ACHIEVEMENT AT SCHOOL (compared to conventional instruction)			TYPE OF TRAINING
				INFERIOR	SAME	SUPERIOR	
CAI	IBM 1500	A	SIGNAL C&S		• • • •	• •	ELECTRONICS
		N	SAN DIEGO			• • • • •	ELECTRICITY
	PLATO IV	A	ABERDEEN		• • •		MACHINIST
		N	SAN DIEGO		• •	• • • •	ELECTRONICS
		N	SAN DIEGO		• •		RECIPE CONVERSION
		N	NORTH ISLAND			•	A/C PANEL OPERATOR
		AF	SHEPPARD		• •	• •	MEDICAL ASSISTANT
		AF	CHANUTE		• • • •		VEHICLE REPAIR
	LTS-3	AF	KEESLER		• •	•	ELECTRONICS
		AF	KEESLER		•		WEATHER
	TICCIT	N	NORTH ISLAND		•		TACTICAL CO-ORD. (S-3A)
	IOBOM	N	DAM NECK	•	•		FIRE CONTROL TECHNICIAN
	PLATO IV	N	DAM NECK		• •		FIRE CONTROL TECHNICIAN
				TOTAL 1	24	15	
CMI	NAVY CMI	N	MEMPHIS		• •		AVIATION FAMILIARIZATION
		N	MEMPHIS		• •		AV. MECH. FUNDAMENTALS
	AIS	AF	LOWRY		•		INVENTORY MGMT.
		AF	LOWRY		•		MATERIEL FACILITIES
		AF	LOWRY		•		PREC. MEASURING EQPT.
		AF	LOWRY		•		WEAPONS MECHANIC
				TOTAL 0	8	0	

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FIGURE 11. Amount of Student Time Saved by CAI and CMI, Compared to Conventional Instruction

METHOD OF INSTRUCTION	SYSTEM	SERVICE	LOCATION	STUDENT TIME SAVINGS (compared to conventional instruction)	TYPE OF TRAINING
CAI	IBM 1500	A	SIGNAL C&S		ELECTRONICS
		N	SAN DIEGO		ELECTRICITY
	PLATO IV	A	ABERDEEN		MACHINIST
		N	SAN DIEGO		ELECTRONICS
		N	SAN DIEGO		RECIPE CONVERSION
		N	NORTH ISLAND		A/C PANEL OPERATOR
		AF	SHEPPARD		MEDICAL ASSISTANT
		AF	CHANUTE		VEHICLE REPAIR
	LTS-3	AF	KEESLER		ELECTRONICS
		AF	KEESLER		WEATHER
	TICCIT	N	NORTH ISLAND		TACTICAL CO-ORD. (S-3A)
	IOBOM	N	DAM NECK		FIRE CONTROL TECHNICIAN
	PLATO IV	N	DAM NECK		FIRE CONTROL TECHNICIAN
CMI	NAVY CMI	N	MEMPHIS		AVIATION FAMILIARIZATION
		N	MEMPHIS		AV. MECH. FUNDAMENTALS
	AIS	AF	LOWRY		INVENTORY MGMT.
		AF	LOWRY		MATERIEL FACILITIES
		AF	LOWRY		PREC. MEASURING EQPT.
		AF	LOWRY		WEAPONS MECHANIC

-40 -20 0 20 40 60 80 100 percent

2-24-81-21

a time saving of about 30 percent. Reductions in the time needed by students to complete their courses, when translated into reduced costs for student pay and allowances, fewer instructors and support, can represent real cost savings due to the use of CAI and CMI. However, life-cycle costs for computer-based and conventional instruction must be considered before we know whether computer-based instruction actually produces overall savings in costs.

MAINTENANCE SIMULATORS

Operational equipment is often used at schools to train technicians how to perform routine maintenance, diagnose malfunctions, and replace faulty parts.

It seems reasonable to do this because trainees will be expected to maintain the same equipment in the field. However, actual equipment tends to be expensive and provides none of the facilities needed to permit adequate instruction such as measures of student performance, feedback of results and easy insertion of malfunctions. Such limitations can be overcome in a simulator and the use of maintenance simulators for training has increased over the last five years.

The effectiveness of maintenance simulators and of actual equipment trainers has been compared in 13 studies conducted from 1967 to 1980 (Figure 12). Five different types of simulators were evaluated. The findings are as follows:

1. Simulators were as effective as actual equipment trainers.
2. Simulators saved some student time.
3. Students favored simulators more than instructors did.

Relatively complete data on the acquisition costs of maintenance simulators and of comparable actual equipment trainers are available in 11 cases. Two estimates for the cost of a maintenance simulator were developed: the high estimate includes the cost of research and development plus the cost of fabricating one production unit; the low estimate includes only the recurring cost. The cost of an actual equipment trainer is the recurring unit cost plus the cost of modifications needed for its use at school.

As shown in Figure 13, the acquisition cost of a maintenance simulator is 0.20 to 0.60 as much as a comparable actual equipment trainer. However, a comparison limited only to acquisition costs overlooks the long-term costs of using simulators and actual equipment trainers.

Only one complete cost comparison of a maintenance simulator and an actual equipment trainer has been found. This was a 15-year life-cycle cost comparison of the Air Force 6883 Avionics Test Bench Three-Dimensional Simulator for the F-111 aircraft and the actual equipment (Cicchinelli, Harmon, Keller and Kottenstette, 1980). The analysis includes all costs for buying, using, and maintaining the equipment, as well as for student and instructor pay and support. On this basis, cost per student hour over a 15-year period would be $60 for the actual equipment and $23 for the simulator or about 40 percent as much for the simulator. The study also found that both were equally effective, as measured by student performance at school and by supervisors' ratings of job performance of course graduates.

Thus, maintenance simulators appear to be cost-effective, compared to actual equipment trainers although, here again, only school data and no transfer data (except for some supervisors' ratings) are available.

PROSPECTS FOR THE FUTURE

Returning now to the framework offered earlier in Figure 3, it should be obvious that training has been assessed almost entirely on the basis of performance at school and with little or no follow-through to the utility of that training in an operational environment. There are no data that relate performance at school to performance on the job or in exercises except in the case of flight training, i.e., from flight simulators to aircraft. Our assessment of the current status of assessment of training is shown in Figure 14. There are major gaps in the types of information that should be available. Progress to fill some of these gaps can be reported.

Within each service, the manpower offices are responsible for policy affecting recruitment, enlistment, training, career planning and, finally, retirement. The manpower data systems contain information relating training and career advancement. To the extent that advancement in career is related to job performance, it is possible that training would have some influence on career progression. Not a strong relationship should be expected here but the issue should be explored.

Skill Qualification Tests (SQTs) provide a means to measure the knowledges and skills required to qualify for military occupational specialties. Assuming that the SQTs are actually relevant to the jobs for which they have been designed, i.e., that they are valid and reliable, they provide a way of measuring job-related skills--though not actual performance on the job. A recent report of the General Accounting Office questions the ability of the Skill Qualification Tests to provide a tool for measuring individual training effectiveness and individual soldier proficiency in critical job tasks (U.S. General Accounting Office, 1982).

The Army Research Institute has started to develop a "Maintenance Performance System." This would provide data, on a routine basis, on how well maintenance personnel perform all maintenance tasks assigned to them in their field units. A prototype version of this system is now being tested. If it proves to be practical and reliable, data on job performance in the area of field maintenance could be related to training at school (e.g.,

FIGURE 12. Studies on the Effectiveness of Maintenance Simulators, 1967-1980

SIMULATOR	COURSE	COURSE LENGTH (STANDARD)	NO. OF SUBJECTS	COMPARISONS: SIMULATOR TO ACTUAL EQUIPMENT					
				EFFECTIVENESS				ATTITUDE TO SIMULATORS	
				POORER	SAME	BETTER	TIME SAVINGS	STUDENTS	INSTR.
Generalized Sonar Maintenance Trainer	Sonar maintenance (special course)	4 days	9		•		22%	+	
	Intermediate General Electronics	4 weeks	20		•				
EC II	APQ-126 Radar		17					+	
	Mohawk Propeller System	3 hrs	33			•			
	Hydraulic and Flight Control	32 hrs	13		•	•		+	−
	Engine, Power Plants and Fuel	24 hrs	13	•	•			+	−
	Environmental/Utility System	32 hrs	9		••			+	−
	APQ-126 Radar	60 hrs	15		••			0/+	0/+
	Pilot Familiarization, T-2C	18 hrs	6						+
	Flight Officer Familiarization, TA-4C	11 hrs	30						+
Generalized Maintenance Training System	SRC-20 UHF Voice Command System		20				ABOUT 50%	+	
	SPA-61 Radar Repeater	16 hrs	10					+	
Fault Identification Simulator	Hagen Automatic Boiler	5 wks	16		•		ABOUT 50%		
6883 Converter/ Flight Control Systems Test Station	F-111 Avionics Maintenance	6 days	56		•			+	0/+

9-22-81-12

FIGURE 13. High and Low Estimates for the Acquisition Costs of Maintenance Simulators/Actual Equipment

	SIMULATOR/AET
HIGH ESTIMATE RDT&E + 1 UNIT	0.60
LOW ESTIMATE RECURRING	0.20

FIGURE 14. Current Status of Assessment of Training

TYPE OF TRAINING	METHOD OF ASSESSMENT	
	EFFECTIVENESS	COST
SCHOOL	CONSIDERABLE DATA	LIMITED DATA
ON-THE-JOB	FLIGHT SIMULATORS	AIRCRAFT ONLY
FIELD EXERCISE		

8-25-82-36

courses taken, method of instruction, and method of selection). There are similar developments in the other services.

The military services operate large data management systems that provide detailed information on the current maintenance status of military equipment (e.g., the Naval Aviation Maintenance and Material Management System, called the "3-M System"). These systems were designed to manage maintenance and logistics activities and not to provide data on the performance of maintenance personnel or how well they were trained. Under ideal circumstances, the Maintenance Performance System, described above, would fill this gap (String and Orlansky, 1981).

However, selected information collected by the maintenance management data systems provide a basis for making inferences about the quality of performance of maintenance technicians in the actual environment of day-to-day work. A specific example concerns data on components removed erroneously during maintenance, i.e., items removed as faulty that were found later not to contain any malfunctions. Such data suggest that the specific individuals involved in inappropriate removals were not meeting performance standards. An inference about incorrect maintenance must be made cautiously because incorrect removals are sometimes due to faulty test equipment.

Nevertheless, data from seven studies on the removal of nonfaulty components suggest that this is a topic of great interest (Orlansky and String, 1981).

1. Nonfaulty components are removed in 4 to 43 percent of all corrective maintenance actions and account for 9 to 32 percent of all maintenance man-hours.
2. Technicians failed to find a faulty part or damaged a good part in about 10 percent of all corrective maintenance actions.

The advent of "embedded training" offers the possibility of another type of job performance data and, perhaps, of exercise data as well. "Embedded training" refers to the use of the computer systems, now found in many military systems, to provide simulated inputs for training purposes and to score the performance of the operators. In effect, many large and small scale operational systems can also be used for traning and for assessing the proficiency of their crews. This clearly provides relevant performance data in an exercise environment at both the individual job level and the crew or unit level.

Another innovation of great importance for the collection of exercise and field performance data is the development of "engagement systems" such as the Multiple Integrated Laser Engagement System (MILES). The system consists of eye-safe lasers mounted on and boresighted with various weapons, such as, rifles, missiles, and artillery. These are energized when the gun fires and are coded so that shots from each individual weapon can be identified. Each person, vehicle, and weapon involved in the field engagement carries a "badge" that detects when a laser (i.e., a weapon) has fired successfully at that target. The result is that military units can maneuver freely with weapons against each other in a battlefield environment; the lasers and detectors provide reliable means for immediate scoring of hits, kills, and misses. This provides a revolutionary way of measuring the effects of aiming, maneuvering, exposure, and use of terrain by opposing groups in almost real battlefield situations.

Although few useful assessment data have been available up to now, means are becoming available to fill the gap between training at school and performance on the job and in military exercises.

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